June 20, 2012

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Re: Comments On Oregon and Washington's 2010 Impaired Waters Lists

I am writing to inform you of two important new studies concerning ocean acidification in the Pacific Northwest. These comments are in support of our request that EPA identify *all* of Oregon and Washington's coastal waters as threatened or impaired by ocean acidification under section 303(d) of the Clean Water Act.

As detailed in previous submissions, our oceans are becoming acidic faster than they have in the past 300 million years (Honisch et al. 2012). The rate of acidification is ten times greater than anything in the geologic record and threatens all forms of ocean life. EPA must provide bold leadership in order to prevent the most harmful consequences of ocean acidification. The time to act is *now*.

The peer-reviewed, scientific studies the Center has submitted for Oregon and Washington's 303(d) lists demonstrate that the ocean waters of both states are threatened and impaired by ocean acidification. In this comment, we would like to describe two fecent studies that support 303(d) listing for Oregon and Washington's waters. In summary, Gruber et al. 2012 modeled ocean acidification and concluded that within forty years more than half of waters in the California Current will be undersaturated with respect to aragonite year-round. This study demonstrates that coastal waters in the California Current are already experiencing deleterious water quality effects due to ocean acidification and that the near future impacts will be severe. Additionally, Hettinger et al. 2012 researched the impacts of ocean acidification on the Olympia oyster, a foundation species in the Pacific Northwest, and noted that with reduced pH levels the juvenile oysters exhibited a 41% decrease in shell growth rate. Notably the negative impacts of exposure to low pH early in the life history of the oysters persisted even when juveniles were returned to higher pH levels. Both of these studies taken together with the Center's prior submissions highlight that ocean acidification is occurring in Washington and Oregon's coastal waters with negative affects on aquatic life meaning that aquatic life water quality standards are not being attained.

Gruber et al 2012 applied both "high" and "low" emissions scenarios to model simulations of ocean acidification in the California Current System up to 2050. These simulations measured the aragonite saturation state (Ω_{ar}), a particularly relevant metric of ocean acidification for organisms that build their structures out of mineral forms of calcium carbonate. Currently, nearly all of the surface ocean waters are substantially supersaturated with regard to aragonite. However, in both scenarios, the Ω_{ar} is projected to drop rapidly, threatening one of the most productive ecosystems in the world and home to many commercial fisheries.

Recent observations along the California Current System revealed that waters with Ω_{ar} lower than one are transported onto the continental shelf during strong upwelling events (Feeley et al. 2008). These upwelled waters are enriched with CO_2 from the remineralization of organic matter in the ocean interior and have naturally low pH and Ω_{ar}. The increase in atmospheric CO_2 since pre-industrial times has contributed to the severity of the event by causing the saturation horizon to shoal by several meters and leading to undersaturated surface waters along the entire Pacific Coast during upwelling seasons (Feely et al 2008). Gruber et al. used their model to identify what levels of ocean acidification the California Current System may experience in the future.

The model predicts that within 40 years half of surface waters will be undersaturated year-round, and that habitats along the seafloor will be exposed to year-round undersaturation within 20-30 years. The model indicates that conditions in the California Current System are rapidly moving well outside the natural range. Since current levels of undersaturation are already causing mass die-offs of Pacific oysters (Barton et al. 2012) in Washington and Oregon, this will have serious implications for the Pacific Northwest's rich and diverse marine life.

For the time period between 1750 and 2005, model simulations showed ocean surface pH for the whole California Current System decreased from an annual mean of 8.12 to 8.04. Over the same period, the annual mean surface Ω_{ar} decreased from 2.58 to 2.27. The model predicts an even sharper decrease up to 2050 with ocean acidification accelerating significantly. Annual mean surface pH and Ω_{ar} will fall to 7.92 and 1.77, respectively, and for the nearshore 10 km environment those numbers will drop to 7.82 and 1.26. Moreover, the model is conservative as demonstrated by actual conditions being observed in the Pacific Northwest where nearshore waters are already being exposed to lower pH levels and undersaturation than described by the model (see e.g., Feely et al. 2008, Feely et al. 2010, Barton et al. 2012, Wootton et al. 2008).

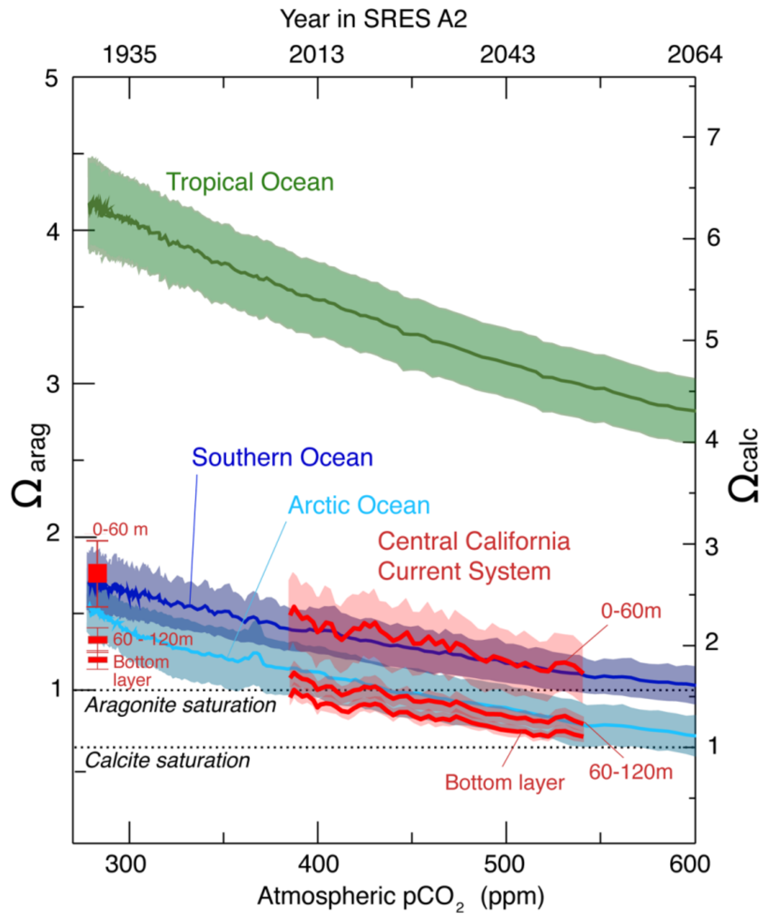

Fig. 1. *Temporal evolution of the mean saturation states with regard to aragonite (left y axis) and calcite (right y axis) in the nearshore 10 km of the central California Current System as a function of the atmospheric partial pressure of CO2, i.e., pCO2 (lower x axis), and time (upper x axis). Depicted are the evolution of three depth layers, i.e., 0 to 60 m, 60 to 120 m, and the bottom layer of the model above the shelf sediments. Also shown are the mean evolutions of Ωarag for the tropical ocean, for the Southern Ocean, and for the Arctic as simulated by a global coarse resolution model (18). Shaded curves depict the modeled trajectories including ±1 standard deviation of the seasonal variations. All simulations are done for the A2 scenario.*

Changes in seawater chemistry will affect not only the surface ocean; changes will also alter carbonate chemistry at depth. The aragonite saturation horizon, originally located at 350 meters in the offshore, and 300 meters in the nearshore, shoaled by about 150 meters from 1750 to 2005, and is projected to shoal by another 100 to 150 meters between 2005 and 2050. For the nearshore annual mean, saturation horizon will be at less than 50 m. During summertime upwelling events, the saturation horizon will break the surface in many areas, meaning these waters will be understaturated with respect to aragonite, severely reducing the habitat for organisms sensitive to the saturation state. When considering the volume of water within a particular saturation state, by the 2050 summer season, 70% of waters in the euphotic zone (0 to 60 meters) will be undersaturated with respect to aragonite. Even more drastic, in waters between 60 and

120 meters, nearly the entire nearshore zone will be undersaturated year-round within the next 20 to 30 years.

Lower saturation states will have wide-ranging impacts on marine organisms. Oyster hatcheries on the Oregon and Washington coast report repeated failures of up to 80 percent of oyster production due, in part, to waters affected by ocean acidification. (Barton et al. 2012; Miller et al. 2009). Oysters in Willapa Bay have also experienced mass mortalities since 2005 and have had no successful natural set since then. A new study by Hettinger et al. 2012, corroborates Barton et al. 2012, where the study of ambient ocean acidification demonstrated significant decline in growth and overall production of Pacific oysters over multiple life stages. Hettinger et al. studied the Olympia oyster, a key component of the Pacific Northwest coastal ecosystem that has had dramatic population declines due to anthropogenic threats. The researchers reared Olympia oysters at three levels of pH, 8.0, 7.9 and 7.8.

Oysters experienced a reduction of growth rate of 41% for juveniles that had been reared as larvae in low pH waters. This reduction in growth occurred even when the oysters were transferred to control pH waters as juveniles. This indicates that Olympia oyster larvae are highly susceptible to ocean acidification, and that the impact is transferred across life stages. The implications for the marine ecosystem and shellfish industry are extremely concerning. The Pacific Northwest's shellfish industry alone is valued at $278 million (Barton et al. 2012).

Gruber et al. noted the drastic and imminent affects of ocean acidification along the West Coast of the United States:

> The projected evolution of the upper ocean in the nearshore 10 km of the center California CS toward low Ω_{ar} conditions is similar to what is projected for the Southern Ocean and the Arctic, which previously have been proposed as the first oceanic regions to become undersaturated. The upper twilight zone and the bottom layer of the center Calfiornia CS become undersatured even faster than the surface Arctic, highlighting the imminent nature of reaching this threshold.

While the conclusions of this study are alarming, the progression of ocean acidification may occur even faster or at lower atmospheric CO_2 concentrations than projected. Gruber et al. admit that their model tends to overproject aragonite saturation in the nearshore regions, so that the appearance of certain thresholds is likely delayed in the model. Furthermore, while their model used current upwelling conditions, model simulations and historical trends suggest that upwelling will increase in the coming decades due to global warming. In addition, because ocean acidification will not be operating in isolation, its impact will be worsened with synergistic effects of ocean warming and ocean deoxygenation, both of which occur in the California Current System.

In conclusion, the threats of ocean acidification are real, and they are negatively impacting Oregon and Washington's aquatic life *today*. The impairment of calcifying organisms, such as oysters and pteropods, from ocean acidification will have devastating impacts on the entire marine food web, and will result in huge economic costs for both Oregon and Washington. EPA must consider these comments, recent studies, and reports as well as other scientific information included herein, and take prompt action to identify Oregon and Washington's coastal and estuarine waters as threatened or impaired by acidification.

Sincerely,

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Enclosed:

Barton, Alan; Hales, B; Waldbusser, G; Langdon, C.; Feely, R.A. 2012. "The Pacific oyster, Crassostrea gigas, shows negative correlation to naturally elevated carbon dioxide levels: Implications for near-term ocean acidification effects." *Limnol. Oceanography*, 57(3) 2012, 698-710. doi: 10.4319/lo.2012.57.3.0698

Comeau A, Jeffree R, Teyssie JL et al. (2010) Response of the Arctic pteropod *Limacina helicina* to projected future environmental conditions. *PLoS ONE*, 5, e11362.

Feely, R.A., CL Sabine, J.M. Hernandez-Ayon, Debby Ianson, and Burke Hales. 2008. Evidence for upwelling of corrosive "acidified" water onto the continental shelf. *Science* 320, no. 5882 (June 13): 1490. doi:10.1126/science.1155676.

Gruber, Nicolas; Hauri, C; Lachkar, Z; Loher, D; Frolicher, T; Plattner, G-K. "Rapid Progession of the Ocean Acidification in the California Current System." Sciencexpress *Reports* (June 14, 2012); doi:10.1126/science.1216773

Hettinger, Annaliese, Sanford, E, Hil, TM, Russell, AD, Sato, KNS, Hoey, J., Forsch, M, Page, HN, Gaylord, B. 2012. Persistent carry-over effects of planktonic exposure to ocean acidification in the Olympia oyster. Ecological Applications (in press).